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Problems on Nuclear Science and Engineering Course

Introduction to Nuclear Engineering (University of Dhaka)

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Problems on Nuclear Science and Engineering Course (NE-1101)

1. A radioactive sample initially contains 2.40×10^{-2} mol of a radioactive material whose half-life is 6.00 h. How many moles of the radioactive material remain after 6.00 h? After 12.0 h? After 36.0 h?

2. Write the complete β−decay equation for ^{90}Sr, a major waste product of nuclear reactors.

3. A large power reactor that has been in operation for some months is turned off, but residual activity in the core still produces 150 MW of power. If the average energy per decay of the fission products is 1.00 MeV, what is the core activity?

4. The electrical power output of a large nuclear reactor facility is 900 MW. It has a 35.0 efficiency in converting nuclear power to electrical power.

   (a) What is the thermal nuclear power output in megawatts?

   (b) How many ^{235}U nuclei fission each second, assuming the average fission produces 200 MeV?

   (c) What mass of ^{235}U is fissioned in 1 year of full-power operation?

5. Calculate the BE/A in MeV for ^{12}C, ^{13}C, ^{239}Pu, ^{56}Fe, ^{235}U, and ^{4}He.

6. Calculate how much (in g/d unit) U-235 should be burned per day if we want to produce 1 MW of thermal power? Consider each fission yields 190 MeV of useful energy and 86% of U-235 are fission occurring.

7. Find out the decay constant of Cesium-137, then calculate the activity in Becquerels and curies for sample containing 3×10^{19} atoms. Given the half-life of Cesium-137 is 30 years.

8. How much uranium needs to be fissioned, when the annual demand of electricity of a city of 1.5 million people is fully covered nuclear energy? Assume annual consumption of electric energy=10^{10} kWh.

9. A ^{60}Co source is labeled 4.00 mCi, but its present activity is found to be 1.85×10^{7} Bq. (a) What is the present activity in mCi? (b) How long ago did it actually have a 4.00-mCi activity

10. A sample of Iodine-131 has an initial activity of 5 mCi. The half-life of I-131 is 8 days. What is the activity of the sample 32 days later?

11. Calculate the decay heat percentage of the original power of 3411 MWth of a PWR resulting from the sudden insertion of control rods in an operating nuclear reactor after the instantaneous stoppage of power generation.

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- 1 second after reactor shutdown
- 1 day after reactor shutdown.

The reactor operated for 1 year at the capacity of 75% of the total power. Draw illustrative diagrams to explain your solution method.

12. Prove that If no cooling or no effective cooling, can cause core heat up in no time due to decay heat. Under this situation, within 15 minutes, the whole reactor core could be melt down. Consider necessary assumptions.

13. Assume a pressurized water reactor (PWR) has experienced a complete shutdown due to a loss of electrical power. Calculate the decay heat generated in the reactor core during a specific time period after the shutdown.
    Given Data:
    Initial Decay Heat Rate: H0 = 300 MW
    Decay Constant: λ = 0.01s−1
    Time After Shutdown: t = 10 hours

14. Calculate the Q value for the exothermic reaction- ${}_4Be^9$ (α, n) ${}_6C^{12}$ and for the endothermic reaction- ${}_8O^16$ (n, α) ${}_6C^{13}$. Assume atomic masses of required atoms.

15. Calculate the Q-values for the following two beta radioactive decays,
    (a) ${}^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + {}^{0}_{+1}e + \nu\ (neutrino)$ (b) ${}^{38}_{17}Cl \rightarrow {}^{38}_{18}Ar + {}^{0}_{-1}e + \bar{\nu}\ (antineutrino)$

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